METHOD AND ARRANGEMENT FOR ESTIMATION OF LINE PROPERTIES

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a method and an arrangement in the area of estimation of line properties of a signal
5 line, such as the line length and line attenuation.

DESCRIPTION OF RELATED ART

In today's telecommunication it is essential from an economical point of view to use existing copper wires for broadband transmission. These copper wires, often called
10 twisted-pair copper loops or copper access lines, have among themselves very different properties from a broadband point of view. Telecom operators therefore have a great interest in testing the properties of the lines to be able to fully utilize their transmission capacity. The above-mentioned is
15 discussed in an article by Walter Goralski: "xDSL Loop Qualification and Testing", IEEE Communications Magazine, May 1999, pages 79-83. The article also discusses testing possibilities and test equipment.

The transmission properties of copper lines are more closely
20 discussed in an article by José E. Schutt-Ainé: "High-Frequency Characterization of Twisted-Pair Cables", IEEE Transactions on Communications, Vol. 49, No. 4, April 2001. Propagation parameters of high bit rate digital subscriber twisted-pair cables are extracted by a wave propagation
25 method model. The frequency dependence in the properties of the transmission line and the influence of the skin effect on these are studied.

Testing the transmission properties of a line can be performed by sending a test signal from one end of the line
30 and measure it at the other end, so called double end test. That method is labour intensive and expensive. A more frequently used method is to send a test signal from one end

of the line and measure on the reflected signal from the line, so called Single-Ended Loop Testing, SELT. In an article by Stefano Galli and David L Waring: "Loop Makeup Identification Via Single Ended Testing: Beyond Mere Loop

5   Qualification", IEEE · Journal on Selected Areas in · Communications, Vol. 20, No. 5, June 2002 is discussed the influence of different types of line discontinuities and generated echoes in connection with single-ended testing. Especially time-domain reflectometry, TDR, is discussed for

10   measuring the length of a line. An outgoing pulse is sent to the line and a reflected pulse is detected. Assuming that the velocity of the pulse is known, then by measuring the time between the two pulses the line length can be estimated. One difficulty with the traditional TDR method is

15   that the reflected pulse can be heavily attenuated and be difficult to detect, as it is hidden by the rather broad outgoing pulse. To avoid this problem the pulses can be filtered, but the Galli and Waring article suggests to instead subtract the outgoing pulse to get a distinct

20   reflected pulse. A mathematical method for handling the echoes is presented and also an experimental validation of the method.

Another problem with the traditional TDR method is that for short lines the outgoing and reflected pulses are close to

25   each other and are difficult to separate of that reason. For a very long line, on the other hand, the reflected pulse is heavily attenuated and can be hidden in the noise. Therefore, in traditional TDR, for some measurements only one pulse is observable and it is impossible to know if it

30   depends on that the line is very short or very long.

In single-ended testing it is advantageous to use the transceiver as a part of a mesurement device for the loop under test. The broadband communication transceiver is no perfect voltage generator but introduces distortion in the

35   measurement. How to remove this distortion is discussed in a

standardization paper by Thierry Pollet :"How is G.selt to
specify S_{11} (calibrated measurements)?", ITU
Telecommunication Standardization Sector, Temporary Document
OJ-091; Osaka, Japan 21-25 October, 2002. A calibration
5 method is presented, based on a one port scattering
parameter S_{11} , that includes transceiver parameters which are
generated during a calibration. Also in a standardization
paper by Thierry Pollet : "Minimal information to be passed
between measurement and interpretation unit", ITU
10 Telecommunication Standardization Sector, Temporary Document
OC-049; Ottawa, Canada 5-9 August, 2002, the one port
scattering parameter S_{11} is discussed.

SUMMARY OF THE INVENTION

The present invention is concerned with a main problem how
15 to estimate the length of a signal line.

Another problem is how to classify the line as being a long
or a short line, prior to the length estimation.

Still a problem is how to perform the length estimation in a
single ended loop test, utilizing a transceiver intended for
20 communication purposes.

A further problem is to estimate a line attenuation.

The problems are solved by generation of an absolute value
of a frequency dependent line input impedance and utilizing
the waveform and periodicity of the absolute value of the
25 line input impedance.

More closely the problems are solved by selecting
consecutive maxima or consecutive minima of the absolute
value of the line input impedance. A frequency distance
between two of the consecutive extreme values is determined.
30 With the aid of the signal velocity of propagation on the
line and the frequency distance the line length is

estimated. An attenuation value is in one embodiment generated based on the length and an attenuation per length unit for the line. In an alternative embodiment extreme values of the absolute impedance value curve are used to
5   estimate the line attenuation.

A purpose with the invention is to estimate the length of the signal line in a simple manner.

Another purpose is to classify the line as long or short before the length estimation.

10   Still a purpose is to facilitate the use of a transceiver for communication purposes in the line length estimation.

Still another purpose is to make the length estimation independent of the hardware in the transceiver.

A further purpose is to estimate a line attenuation.

15   An advantage with the invention is that the line can be decided as short before the length estimation.

Another advantage is that a reliable length value can be estimated for short lines.

Still an advantage is that a transceiver for communication
20   purposes can be calibrated and used for the estimation.

Still another advantage is to make the length estimation independent of the hardware in the transceiver.

A further advantage is that the line attenuation can be generated in a simple manner.

25   The invention will now be more closely described with the aid of embodiments and with refernce to the enclosed drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figur 1 shows a block schematic over measurement device connected to a line;

5   Figure 2 shows a diagram with line impedance for different lines;

Figure 3 shows a diagram with line impedance for one line;

Figure 4 shows a flow chart over a method of line length
10   estimation;

Figure 5 shows a block schematic over a transceiver connected to a line;

15   Figure 6 shows a somewhat more detailed block schematic over a transceiver;

Figure 7 shows a block schematic over a test transceiver connected to a test impedance;
20
Figure 8 shows a flow chart over a method of generating transceiver model values;

Figure 9 shows a flow chart over a method of generating a
25   line impedance value; and

Figure 10 shows a flow chart over a method of generating a line attenuation value.

30   **DETAILED DESCRIPTION OF EMBODIMENTS**

In figure 1 is shown a front end device, a measurement device MD1, connected to a customer's remote device 3 via a signal line 2 having a length L. This signal line is a

copper wire initially used for narrowband signal transmission. A signal on the line 2 propagates with a velocity *vop* · m/s. As mentioned above it is of great interest for telecommunication operators to use such lines

5   for brodband transmission and therefore the properties of the line 2 must be known, such as the line length L. The properties of the line are therefore to be measured, which can be performed by different methods.

10   One such method is shown in figure 1. The measurement device MD1 has a line unit LU1 and a calculation unit CU1 connected to each other. The measuring device MD1 has a control input/output IU1. The line unit has a frequency broadband voltage source VS1 with a voltage E and an impedance Z_s and

15   also a voltage measurement device VM1 measuring a line input voltage V_1. A frequency dependent line input impedance $(Z_{in}(f))$ for a loop including the line 2 and the remote device 3 can be calculated by an equation

$$V_1 = \frac{Z_{in}}{Z_{in} + Z_S} E \qquad (1)$$

20

The calculation is performed in the calculation unit CU1.

In the present invention the frequency dependent line input impedance $Z_{in}(f)$ is used to generate an estimated value of

25   the line length L. It is observed that the impedance $Z_{in}(f)$ is a function that has a part that is periodic with the frequency as is shown in figure 2. This figure is a diagram with the frequency f on the abscissa and an absolute value $|Z_{in}(f)|$ of the line input impedance on the ordinate.

30   The diagram shows curves over measurements of the absolute value $|Z_{in}(f)|$ of the input impedance $Z_{in}(f)$ for different lengths of the signal line 2. The signal line is a cable of certain type and the remote device 3 is in the embodiment a telephone set in the on-hook state. The cable lengths,

denoted in kilometers the diagram, are 0.5 km, 1.0 km and
1.5 km. It appears from the diagram that the period for the
respective curve is different for the different cable
lengths.

In figure 3 is shown an impedance diagram for only one
signal line having the length L. The diagram has the
frequency f on the abscissa and the absolute value $|Z_{in}(f)|$
of the line input impedance on the ordinate. In this diagram
is shown an impedance curve A1 which is essentially
periodic and is generated by a number of samples A2 at
mutual frequency distance of Δf. The curve A1 has a number
of extreme values of which maximums Max1, Max2, Max3 and
minimums Min1, Min2 , Min3 are shown. The frequency
distance between two consecutive of the extreme values of
the same type is denoted by FD1, FD2, FD3 and FD4
respectively. The line length L can now be estimated by
using the distance FD1 and with the aid of the velocity of
propagation vop by an equation:

L= ½ vop/FD1   (2)

This equation can alternatively be expressed as

$$L = \frac{1}{2} \frac{vop}{cycle \cdot \Delta f} \qquad (3)$$

In the equation (3) the expression $cycle$ is the "cycle
time", i.e. the periodicity, of the input impedance $|Z_{in}(f)|$
expressed in number of the samples A2 between two
consecutive maximums or minimums of the curve A1.

The velocity of propagation vop is about 0.7 of the
velocity of light in vaccum, i.e $vop \approx 2 \cdot 10^{8}$ m/s. In the
example in figure 3 the frequency distance is FD1$\approx$200 kHz.
The line length can be estimated by the equation 2 to about
L=500 m.

The length estimation of the line 2 can be improved by
using more than one of the frequency distances. As
mentioned above the curve A1 is essentially periodic. It
has however been observed that, in some cases depending on
5   the type of termination, the frequency distance FD2 is
slightly longer than the distance FD1 and correspondingly
the distance FD4 is slightly longer than the distance FD3.
For higher frequencies the frequency distances successively
grows still a little bit. This fact depends on that, in the
10   actual cases, the velocity of propagation vop increases
with increasing frequency. Mean values MV1 and MV2 can be
generated for the frequency distance by e.g. the equations

$$MV1 = (FD1+FD2)/2 \qquad (4)$$
15 $$MV2 = (FD3+FD4)/2 \qquad (5)$$
The line length L is estimated as
$$L = \tfrac{1}{2} \, vop/MV1 \qquad (6)$$
$$L = \tfrac{1}{2} \, vop/MV2 \qquad (7)$$

20   Still an improvement is to use both the maximums and the
minimums e.g. by generating a mean frequency distance

$$MV3 = (MV1+MV2)/2 \qquad (8)$$

25   and estimate the line length as

$$L = \tfrac{1}{2} \, vop/MV3 \qquad (9)$$

In the above examples the frequency distances between three
30   maximums or minimums have been used. In an obvious way it
is possible to use still further of the extreme values of
the curve A1 to generate the length estimate L of the line
2. The type of averaging depends on the type of termination
of the line, i.e. the type of the remote device 3. If the
35   termination is known in a certain case it is possible to
choose the most appropriate averaging.

As appears from figure 2 the amplitude oscillation in the signal $|Z_{in}(f)|$ is larger for a short than for a long loop. This means that the estimated length value L will be less exact for a long loop. It is therefore of interest to estimate if a loop can be regarded as short. Below is disclosed how the input impedance, $Z_{in}(f)$, can be used for this purpose, short loop detection. The basic principle is to calculate a decision value *dValue* and compare it with a threshold value *thValue*, which threshold value should cover realistic telecommunication cables. The threshold value depends on the different attenuation for the different types of cables. A decision value can be calculated as follows:

$$mValue = \frac{1}{f_2 - f_1} \sum_{f=f1}^{f2} |Z_{in}(f)| \qquad (10)$$

where f_1 and f_2 are design parameters that represent the lowest and highest frequency to consider. The *mValue* is a mean value of the curve A1 in the actual frequency range.

$$dValue = \sum_{f=f1}^{f2} |(|Z_{in}(f)| - mValue)| \qquad (11)$$

The *dValue* corresponds to an energy value for the fluctuations of the curve A1 in the actual frequency range. If the $dValue \geq thValue$ the loop should be considered as short. The value *thValue* is a design parameter that sets the limit for when a loop shall be considered short.

The decision of short loop length and generation of the length for the signal line 2 as described above will be described in concentrate in connection with a flow chart in figure 4.

In a first step 401 the line input impedance $Z_{in}(f)$ is generated. The absolute value $|Z_{in}(f)|$ of the line input

impedance is generated in a step 402. In a step 403 the
mean value *mValue* according to equation (10) is generated
and in a step 404 the decision value *dValue* according to
equation (11) is generated. The threshold value *thValue* is
5   decided in a step 405 for the actual telecommunication
cable type in the line 2. The decision is based on the
attenuation for the cable type. In a step 406 it is
investigated if the decision value is bigger than the
threshold value. In an alternative NO the procedure is
10   stopped in a step 407. In an opposite alternative YES the
procedure goes on in a step 408 with the selection of
extreme values of the curve A1 for the absolute values of
the line input impedance. The frequency distance is
generated, alternatively as a mean value of a number of
15   frequency distance values, see equations (4), (5) or (8).
In a step 410 the line length value L is generated, see
equations (6), (7) or (9).

In the description above the line input impedance $Z_{in}(f)$ for
20   the line 2 is measured via the measurement device MD1. It
is an advantage for a telecom operator if a conventional
transceiver for communication purposes can be used instead
of a special measurement device such as the device MD1.
Below will be described how such a transceiver can be
25   calibrated and used for the measurement of the line input
impedance $Z_{in}(f)$ in a single-ended loop test SELT.

In figure 5 is shown a front end device, in this case a
transceiver 1, connected to the remote device 3 via the
30   signal line 2. The transceiver is suitable for
communication purposes and is described such that the SELT
measurement can be explained. The transceiver 1 includes a
digital part 41, a codec 42 and an analog part 43, the so
called Analog Front End AFE. The digital part includes in
35   turn a digital signal generator 13 and a computational

device 11 interconnected with a memory device 12. The
transceiver 1 also has an input 63 and an output 64. The
generator, which is connected to the computational device
11, sends a broadband input loop test signal v_{in} to the

5   remote device 3 via the codec 42, the analog part 43 and
the line 2. A reflected broadband loop test signal v_{out} is
received in the computational device from the line 2 via the
analog part and the codec.

The broadband loop test signal v_{in}, sent for such measuring

10   purposes, is reflected back over the line 2 and is noted as
the loop test signal v_{out}. As will be described below, the
signals v_{in} and v_{out} are used in the   determining of the
properties of the line 2.

What the operator in fact needs to know is the input

15   impedance $Z_{in}(f)$ of the line 2 including the remote device 3,
measured from a transceiver interface 5 and being
independent of the transceiver 1 itself. A first step in
getting the required line properties is to generate an echo
transfer function $H_{echo}(f)$ for the actual line 2. This is

20   calculated by performing a frequency translation of the
broadband signals v_{in} and v_{out}, resulting in signals $V_{in}(f)$
and $V_{out}(f)$ in the frequency domain. The transfer function is
generated by the relationship

$$H_{echo}(f) = V_{out}(f) / V_{in}(f) \qquad\qquad (12)$$

25   in which the frequency is denoted by f.

Naturally, the function $H_{echo}(f)$ includes properties of the
transceiver 1. Below it will be described by an example how
the required line properties of the line 2 can be obtained
with the aid of the frequency dependent echo transfer

30   function $H_{echo}(f)$. First, the transceiver analog part 43 will
be described somewhat more in detail in connection with

figure 6. This is to throw light upon the difficulties in characterizing the transceiver 1 in a simple manner.

Figure 6 is a simplified block diagram over the analog
5   transceiver part 43 and the line 2 of figure 5, yet somewhat more detailed than in that figure. The analog part 43 includes an amplifier block 6, a hybrid block 7, a sense resistor RS and a line transformer 8. The amplifier block 6 has a driver 61 with its input connected to the digital
10 generator 13 via the codec 42, not shown. I also has a receiver 62 receiving signals from the line 2 and having its output connected to the transceiver digital part 41, not shown. The driver output is connected to the sense resistor RS, the terminals of which are connected to the
15 hybrid block 7. The latter has four resistors R1, R2, R3 and R4 and is connected to inputs of the receiver 62. The line transformer 8 has a primary winding L1 and two secondary windings L2 and L3 interconnected by a capacitor C1. The primary winding L1 is connected to the sense
20 resistor RS and the secondary windings L2 and L3 are connected to the line 2. The frequency dependent line input impedance at the interface 5 is denoted $Z_{In}(f)$ and the input impedance at the primary side of the transformer is denoted ZL. The termination of the far-end of the line 2, the
25 remote device 3, is represented by an impedance ZA.

The signal v_{in}, now in analog form from the codec 42, is amplified in the driver block 61. The output impedance of the driver is synthezised by the feedback loop from the
30 sense resistor RS. The line transformer 8 has a voltage step-up from the driver to the loop. The capacitor C1 has a DC-blocking function. The transformer and the capacitor act as a high pass filter between the driver 61/receiver 62 and the loop 2, 3 with a cut-off frequency around 30 kHz. No
35 galvanic access to the loop is possible in this case.

In the present description a frequency-domain model of the echo transfer function $H_{echo}(f)$ is used to calculate the frequency dependent input impedance $Z_{in}(f)$ of the loop 2 and 3, as seen by the transceiver 1 at the interface 5. The

5   input impedance can then be used for calculating several loop qualification parameters. This frequency-domain model of the echo transfer function $H_{echo}(f)$ includes three parameters $Z_{h0}(f)$, $Z_{hyb}(f)$ and $H_{\infty}(f)$ which relate to the transceiver 1. The parameters, transceiver model values,

10   fully describe the transceiver from this point of view.

The parameters $Z_{h0}(f)$, $Z_{hyb}(f)$ and $H_{\infty}(f)$ are originally deduced analytically from the circuits of the transceiver. Some minor simplifications have been made in the analysis,

15   but the model has proved to be very accurate.

The values of the parameters are normally not calculated directly from the component values of the transceiver, but are generated from measurements in a calibration process,

20   as will be described below.

In the earlier mentioned standardization paper "How is G.selt to specify S_{11} (calibrated measurements)?" the scattering parameter S_{11} is expressed with three parameters

25   C1, C2 and C3 for the transceiver. These parameters should not be confused with the transceiver model values $Z_{h0}(f)$, $Z_{hyb}(f)$ and $H_{\infty}(f)$ of the present description. The parameters C1, C2 and C3 are dimensionless quantities and are not given any concrete meaning, although they are successfully

30   used to model the transceiver. The transceiver model values of the present description are recognized in the analysis and can be interpreted directly:

The value $H_\infty(f)$ is the frequency dependent echo transfer function for the transceiver 1 with open connection to the line 2, i.e. when the line impedance is of unlimited magnitude.

5

The value $Z_{hyb}(f)$ is the transceiver impedance as measured at the connections to the line 2, i.e. the transceiver impedance at the interface 5 as seen from the line side. The value $Z_{h0}(f)$ can be expressed as $Z_{h0}(f) = H_0(f) \cdot Z_{hyb}(f)$,

10   in which the value $H_0(f)$ is the frequency dependent echo transfer function for the transceiver 1 with the connections to the line 2 shortcut and the value $Z_{hyb}(f)$ is defined above.

15   It is to observe that the transceiver model values are not measured directly, but are generated in a process as will be described below.

The echo transfer function $H_{echo}(f)$ of equation (1) can be

20   expressed as:

$$H_{echo}(f) = \frac{H_\infty(f)Z_{in}(f) + Z_{h0}(f)}{Z_{in}(f) + Z_{hyb}(f)} \tag{13}$$

in which

$Z_{in}(f)$ is the earlier mentioned input impedance of the line 2 as a function of the frequency f; and

25    $Z_{h0}(f)$, $Z_{hyb}(f)$ and $H_\infty(f)$ are complex vectors and are the transceiver model values mentioned above.

After a calibration measurement of a certain transceiver version its vectors can be determined. These vectors, the

30   transceiver model values, are then pre-stored in for example the software of the transceivers of the measured version, e.g. in the memory 12 of the transceiver 1. The

model values are then used for the loop test of the line 2
with its initially unknown properties.

In connection with figure 7 will be mentioned how the
5   calibration measurement is performed. The figure shows a
test transceiver 31, to which test impedances 9 of
different predetermined values are connected at the
interface 5 for the line 2. A measurement device 32 with a
memory 33 is connected to the input 63 and the otput 64 of
10   the test transceiver. The measurement device 32 sends a
control signal VC1 to the test transceiver 31 and initiates
it to generate a broadband transceiver test signal vt_{in} ,
one for each value of the test impedance 9. A reflected
output transceiver test signal vt_{out} is received in the test
15   tranceiver, which sends a corresponding control signal VC2
to the measurement device. A complete measurement requires
the measurement of three selected impedance values. The
echo transfer function $H_{echo}(f)$ is then generated in
accordance with the relationship (12).
20

Using three impedance values for the calibration is
sufficient to generate the transceiver values. To get more
precise values, more than the three impedances can be used.
This gives rise to an overdetermined equation system. An
25   example on a set of standard values of the test impedance 9
for the calibration is an open circuit, a shortcut circuit
and an impedance value corresponding to an expected value
for the loop, e.g. 100 ohms. It should be noted that a
value for a purely resistive component is normally valid
30   only up to a limited frequency, e.g. 1 MHz. For higher
frequencies it is recommended to measure the impedance
value of the "resistive" component.

The generation of the three complex vectors $Z_{h0}(f)$, $Z_{hyb}(f)$
35   and $H_{\infty}(f)$ for the measured transceiver 31 is performed in

the following manner. The model of the echo transfer function in the relationship (13) can be expressed as:

$$(1 \quad -H_{echo}(f) \quad Z_{in}(f)) \begin{pmatrix} Z_{ho}(f) \\ Z_{hyb}(f) \\ H_{\infty}(f) \end{pmatrix} = H_{echo}(f)Z_{in}(f) \tag{14}$$

5   or equivalently $Ax=b$, where

$$A = (1 \quad -H_{echo}(f) \quad Z_{in}(f)), \qquad x = \begin{pmatrix} Z_{ho}(f) \\ Z_{hyb}(f) \\ H_{\infty}(f) \end{pmatrix} \quad \text{and} \quad b = H_{echo}(f)Z_{in}(f)$$

The general solution to the system $Ax=b$ is

$$x = \left(A^T A\right)^{-1} A^T b$$

By using the values of the transfer function $H_{echo}(f)$,
10   measured as described above with different types of the input terminations 9, the vector x can be solved. The thus generated calibration values of the vector x are stored for example in the memory 33 of the measurement device 32 or in the memory 12 of the transceivers of the measured version.
15   Note that A, x and b normally are complex valued and frequency dependent.

After a measurement of the echo transfer function $H_{echo}(f)$ for the actual unknown line 2, its input impedance as seen
20   by the transceiver 1 at the interface 5 can be generated as:

$$Z_{in}(f) = \frac{Z_{ho}(f) - Z_{hyb}(f)H_{echo}(f)}{H_{echo}(f) - H_{\infty}(f)} \tag{15}$$

To summarize, a certain hardware for transceivers like the transceiver 1 is first calibrated. This is performed for
25   the test transceiver 31 with the aid of the impedances 9 and the transceiver test signals vt_{in} and vt_{out}. The vector x is calculated and the values of the vector x are stored and can be used for any transceiver with the same hardware. The echo transfer function $H_{echo}(f)$ is then measured by the

transceiver 1 for the line 2 having unknown properties with
the aid of the loop test signals v_{in} and v_{out}. The frequency
dependent input impedance $Z_{in}(f)$ of the line 2, as seen from
the transceiver interface 5, is then generated.

5

In the embodiment described above, both the transceiver
test signals vt_{in}, vt_{out} and the loop test signals v_{in}, v_{out} have
been broadband signals. It is possible to use signals of
any desired frequency width both for the calibration and
10 the measurement of the line. The calibration and the loop
test will of course be valid only for the selected
frequency range. It has been mentioned that the transceiver
model values are stored in the memory 12 of the transceiver
1. An obvious alternative is to store the values in the
15 memory 33 or in a memory in some central computer and
transmit them to the transceiver 1 when they are required
for the generation of e.g. the input impedance $Z_{in}(f)$ of the
line 2. Also, in the description has been mentioned the
test transceiver 31 and the transceiver 1 for communication
20 purposes. The test transceiver 31 can be any of a set of
transceivers which are based on one and the same hardware.
The test transceiver can in an obvious way be used for the
communication purposes.

25 The above generation of transceiver model values and the
generation of the impedance value for the line 2 will be
shortly described in connection with flowcharts in figures
8 and 9.

30 In figure 8 is shown the generation and storage of the
transceiver model values. The method begins in a step 601
with the selection of the transceiver 31 for test purposes.
In a step 602 an impedance 9 with a predetermined value is
selected and in a step 603 the impedance is connected to
35 the line connection of the test transceiver 31. In a step

604 the transceiver test signal vt_{in} is sent through the transceiver 31 to the line 2. To get transceiver model values that can be used for a wide range of applications the test signal is a broadband signal. The signal is reflected by the remote device 3 and after passage of the transceiver 31 it is received as the transceiver test signal vt_{out} in a step 605. In a step 606 the echo transfer function $H_{echo}(f)$ is generated in the computational device 32 for the actual impedance 9, after first having transformed the signals vt_{in} and vt_{out} into the frequency domain. In a step 607 it is investigated whether measurements for a sufficient number of the impedances 9 have been made, so that the transceiver model values $Z_{ho}(f)$, $Z_{hyb}(f)$ and $H_{\infty}(f)$ can be generated. In an alternative NO1 a further impedance 9 is selected in the step 602. For an alternative YES1 the transceiver model values $Z_{ho}(f)$, $Z_{hyb}(f)$ and $H_{\infty}(f)$ are generated in a step 608. In a step 609 the vector x, i.e. the transceiver model values, are stored in the memory 33. Next, the transceiver 1 for communication purposes is selected in a step 610. In a step 611 the transceiver model values $Z_{ho}(f)$, $Z_{hyb}(f)$ and $H_{\infty}(f)$ are transmitted to the selected transceiver 1 and are stored in the memory 12.

Figure 9 shows the generation of the frequency dependent line input impedance $Z_{in}(f)$ at the transceiver interface 5 to the line 2. In a step 701 the transceiver 1 for communication purposes is connected to the line 2 with the remote device 3. The loop test signal v_{in} is sent in a step 702. The loop test signal v_{out} as reflected by the line 2 is received by the transceiver and is measured in a step 703. In a step 704 the frequency dependent echo transfer function $H_{echo}(f)$ is generated in the computational device 11. The frequency dependent impedance value $Z_{in}(f)$ for the line 2 is generated in the device 11 with the aid of the

stored transceiver model values and the echo transfer
function, step 705. This generating is performed in
accordance with the relationship (15).

5   An essential property of the signal line 2 is its signal
attenuation. For lines that can be regarded as short this
attenuation can be estimated in a simple manner with
sufficient accuracy. A requirement for this is that the
length L of the line is estimated with good accuracy, e.g.
10   as described above. The method will be described in
connection with a flow chart in figure 10. In a first step
101 an average attenuation value AA1 is calculated for a
selected set of normally used telecommunication cables. An
example on such an average value is AA1=11 dB per
15   kilometer. The line length L of the actual short line is
estimated with good accuracy in a step 102. In a step 103 a
line attenuation value LA1 is generated by multiplying the
line length L with the average attenuation value AA1. In an
embodiment, with reference to figure 1, the method is
20   performed by writing the average attenuation value AA1 via
the control input/output IU1 and storing it in the
calculation unit CU1. The line input impedance $Z_{in}(f)$ is
calculated in accordance with equation (1) and the line
length is estimated by calculations in the calculating unit
25   CU1. In the same unit the line attenuation LA1 is
generated.

Another possibility to estimate a value on the line
attenuation would be to use the ratio between a minimum and
30   an adjacent maximum value of the magnitude of the absolute
impedance value $|Z_{in}(f)|$, the curve A1 in figure 3. The
estimation is performed using an equation:

$$loss = \tanh^{-1}\left(\sqrt{\frac{|Z_{in,min}|}{|Z_{in,max}|}}\right)$$ (16)

As an example the minimum value Min1 and the adjacent maximum value Max1 are used, which gives:

$$loss = \tanh^{-1}\left(\sqrt{\frac{|Min1|}{|Max1|}}\right) \qquad (17)$$

The value *loss* is the insertion loss value that the line 2 gives rise to when inserted between the transceiver 1 and the remote device 3 in figure 5.